International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)
ISSN(P): 2249-6866; ISSN(E): 2249-7978
Vol. 7, Issue 2, Apr 2017, 15-22

OPTIMIZATION AND EFFECTIVENESS OF BRIDGE CONSTRUCTION DEVELOPMENT BASED ON VALUE ENGINEERING

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ABSTRACT

Bridge construction is a very important infrastructure because it connects two separate places due to several conditions. This research was done under the bridge of Lamnyong Bridge doubling construction in Banda Aceh, by providing the most economical costs but still meet the strengthen requirements specified or without losing the value and function of the building. The scope of this research is limited to the implementation cost of under Lamnyong Bridge construction structural works, such as: foundation, bridge abutments and pillars works. The method used in this research is value engineering method that is analysis oriented to evaluate the function of construction project planning of the work. This analysis has a systematic and focused approach in evaluating the object being surveyed. The objective of this study is to apply value engineering to the construction implementation method of concrete conventional bridge construction. There are some implementation phases in value engineering, they are information phase continuing to identify the budget starting from the highest to the lowest prices by using Pareto law distribution graph the creative phase by using cost/worth method, analysis phase and the last is recommendation phase. From the value engineering application of the early design with the budget is 72,486,508,196.71 IDR then carried out some alternatives, they are alternative I obtained the cost is 40,616,598,222.56 IDR or it is 43.97% cost saving, for alternatives II obtained the cost is 41,699,143,562.90 IDR or it is 42.47% cost saving and alternative III obtained the cost is 41,243,208,716.90 IDR or it is 43.10% cost saving. Therefore value engineering method can optimize project cost saving in order to improve effective development quality.

KEYWORDS: Bridge Construction, Value Engineering & Optimization

Received: Jan 30, 2017; **Accepted**: Mar 16, 2017; **Published**: Mar 20, 2017; **Paper Id.**: IJCSEIERDAPR20172

Original Article

INTRODUCTION

Good transportation infrastructure and facility will smooth the traffic flow to be safe, comfortable and afficient from both time and cost sectors. Therefore, road and bridge as the infrastructure must get the primary attention in development. The bridges condition that are less good or inadequate can obstruct the traffict smooth, so it is necessarary doubling or widening of the bridges to overcome the problems and it is useful to smooth the traffic.

The optimization and effectiveness need of project budget requires well planned project technique and controlling. Value engineering is a creative and planned approach that has the objective to identify and create the efficiency of the unnecessary cost. It can be done by revising the project design to allow the cost saving without reducing the quality and function of the project itself.

Lamnyong Bridge doubling construction in Banda Aceh especially for the work done under the bridge can be carried out by value engineering approach because it can give possitive effect. The objective of the bridge doubling construction is to overcome the traffic jam that offen occur as the results of vehicle growth that become more crowded. This research is to identify the works that can be done by value engineering to the cost of the works under the bridge and find the best alternatives that can replace the early design to the selected work items, and to know the project cost difference between the project that has been early planned and the project that has been done the value engineering analysis.

MATERIAL AND METHOD

Bridge

Supriyadi and Muntohar (2007) stated that bridge is very important infrastucture because it has the function as the connection between two seperate places because of some conditions. The bridge planning and design should consider the function of transportation need, technical requirements and aesthetic-architectural including traffic, technical and aesthetic aspects.

The parts of the bridge including upper structure, surface, under structure, foundation, oprit, bridge savety construction. Beside the bridge parts, there are also bridge components such as girder, abutment (bridge placement), roiling (bridge roiling pole), bridge floor plate.

Value Engineering

Soeharto (1995) stated that value engineering is the systematically organized effort applying the recognized technique, it is the technique that identify the product and service functions which objective is to meet the required function to the lowest price (the most economical).

According to Wilson (2005), value engineering is defined as the effort that is systematic and organized done to analyze system, product and service functions to achieve or conduct the essential function of the lowest life cycle cost and consistent to the required performance, reliability, quality and security. Life cycle cost is live cycle cost model to show the total cost of the ownership for each building system, sub system, functional area and maintenance cost.

Value Engineering Application

Wilson (2005) mentioned that the value engineering will be effective if it is applied as early as possible in design phase to produce most possible cost saving. Value engineering theory can be applied in every phase during the project run. But if value engineering application is applied later, it will reach smaller cost saving potential, while the cost create the change because of value engineering will be higher. At a time, cost saving potential and changing cost will reach the break even and it means no cost saving achieved.

Value

According to Kelly & Male (2004), value is defined as the relation among cost, time and quality which the quality consicts of a number of variables determined from someone skill and experience or some people in a group, explicit made to decide choices among various suitable function options.

Cost

Dell'Isola (1997) stated that cost is sum of all efforts and expenditures executed in developing and producing the products. The cost analysis improved because value engineering has the objective to detect the relation between the actual function and cost required and provide decision making method regarding next required efforts.

Function

Function is not anything but an expected performance. Someone buy something based on the function and result (*outcomes*) achieved from something. Design analysis of a component must determine the componen function and feature designed to obtain required results (Kaufman & Jerry,2006).

High Cost Identification

According on Berawi (2014), there are some techniques used to identify the high cost, they are breakdown analysis, cost model, function analysis, life cycle cost impact. Value basic theory is the relation between cost and worth.

$$Value = \frac{Cost}{Worth} > 1 \tag{1}$$

Value Engineering Job Plan

Kelly & Male (2004) defined the job plan is a systematic approach of value engineering. This job plan is directed plan to carry out the value engineering including result implementation of the value engineering. Job plan also become a success key determinant of value engineering study. The phases in value engineering application are information phase, creative phase, analysis phase and recommendation phase.

Research Phase

The research was carried out under bridge work of Lamnyong Bridge doubling in Banda Aceh that connect Banda Aceh Boundery Road Section to Darussalam, with span length is 307.6 m and width is 10.0 m (1,75 x 2 m). Value engineering analysis is carried out in four phases, they are information phase, creative phase, analysis phase and recommendation phase. The phases are explained as below:

Information Phase

The steps applied in information phase mentiones as below:

- Information design repitition;
- Study target determination;
- Element selection with optimum cost saving potency.

Creative Phase

This creative phase uses brain storming method that is one of the tools/techniques used in creative phase to produce the ideas relted to other method to perform the functions. Brain storming is also a technique that is almost always done in value engineering application. The alternatives can be viewed from the various aspects, they are:

- Material;
- Work implementation method;
- Work implemetation time.

Analysis Phase

The methods used in assessment and alternatives selection are benefit and loss analysis methods by giving the value and ranking. To produce the cost saving, value engineering can be done by five phases, they are:

- Material used replacement in the work items
- Getting the work items that will be carried out the value engineering.
- Finding the best alternative design to replace the early designin the selected work items.
- Alternatives design collection.
- Calculating the cost saving from value engineering application.

Recommendation Phase

This is the last phase in value engineering planning by collecting all the results of information, creative, and analysis phases and then all the phases summarized so that it can be recognized which items that can be replaced from the work selected items and how much the cost saving can be achieved after applying the value engineering then make a report to decide which design will be selected and better to be carried out.

RESULT AND DISCUSSIONS

Result

Table 1: High Cost Identification

No.	Work Item	Cost		Cummulative	
		IDR	%	IDR	%
1	Steel Piles Procurement: 500 mm of diameter and 10 mm of the thickness	33.738.468.578,31	45.70	33.738.468.578,31	45.70
2	Reinforcing Steel of screw BJ 32	10.987.079.719,29	14.88	44.725.548.297,60	60.59
3	Procurement of Precast Pre stressed Concrete Piles: 500 mm of diameter	8.789.732.012,35	11.91	53.515.280.309.95	72.49
4	Type I girder precast unit: 26.6 m of the span length	4.293.102.138,08	5.82	57.808.382.448,03	78.31
5	Medium quality concrete with fc '= 30 MPa (K-350)	3.169.152.516,03	4.29	60.977.534.964,07	82.60
6	Medium quality concrete with fc'= 25 MPa (K-300)	2.603.791.422,92	3.53	63.581.326.386,99	86.13
7	Type I girder precast unit: 31,6 m of the span length	2.249.950.754,04	3.05	65.831.277.141,03	89.17
8	Pile staking of precast reinforced concrete: 500 mm of diameter	2.229.916.489,86	3.02	68.061.193.630,89	92.20
9	Deck Slap Procurement	1.151.898.750,00	1.56	69.213.092.380,89	93.76
10	Mobilization	1.141.820.000,00	1.55	70.354.912.380,89	95.30
11	Sheet Pile	1.031.736.309,20	1.40	71.386.648.690,08	96.70

Table 1: Contd.,					
12	Pile staking of Steel Pipe: 500 mm of diameter and 12 mm of the thickness	468.942.593,28	0.64	71.855.591.283,37	97.34
13	Medium quality concrete with fc'= 20 MPa (K-250)	438.181.767,03	0.59	72.293.773.050,40	97.93
14	Railing	337.720.326,50	0.46	72.631.493.376,89	98.39
15	Concrete Diaphragm K350 (fc '30 MPa) including tension work after casting	243.758.492,89	0.33	72.875.251.869,78	98.72
16	Additional cost for item 7.6.(7) s/d 7.6.(10) for pile	177.431.847,91	0.24	73.052.683.717,69	98.96
17	Elastomer placement for type 1 (300 x 350 x 36)	147.349.752,90	0.20	73.200.033.470,60	99.16
18	Low quality concrete with fc'= 15 MPa (K-175)	144.604.980,25	0.20	73.344.638.450,84	99.35
19	Expansion Joint of Type Asphaltic Plug	111.212.130,00	0.15	73.455.850.580,84	99.50
20	Reinforsing steel of plain BJ 24	69.884.952,02	0.09	73.525.735.532,86	99.60
21	Ultility relocation and existing PDAM (Drinking Water Institution) Service	60.000.000,00	0.08	73.585.735.532,86	99.68
22	Ultility relocation and existing PLN (Electricity Institution) Service	60.000.000,00	0.08	73.645.735.532,86	99.76
23	Ultility relocation and existing and other services	50.000.000,00	0.07	73.695.735.532,86	99.83
24	Concrete Demolition	41.192.953,55	0.06	73.736.928.486,41	99.88
25	Additional filler	27.018.749,90	0.04	73.763.947.236,31	99.92
26	Stone masonry	24.528.668,31	0.03	73.788.475.904,62	99.95
27	Traffic Management and Savety	20.000.000,00	0.03	73.808.475.904,62	99.98
28	Quality Management	5.000.000,00	0.01	73.813.475.904,62	99.99
29	Demolition product transportation exceeding 5 km	4.289.461,92	0.01	73.817.765.366,54	99.99
30	Rip rap	3.374.616,04	0.00	73.821.139.982,58	100.00
31	Bridge Name Plank	1.666.964,03	0.00	73.822.806.946,61	100
	Total	73.822.806.946,61	100	73.822.806.946,61	100

After high cost analysis phase then it is carried out analysis phase to pareto graph to detect the percentage of cost cummulative and work items.

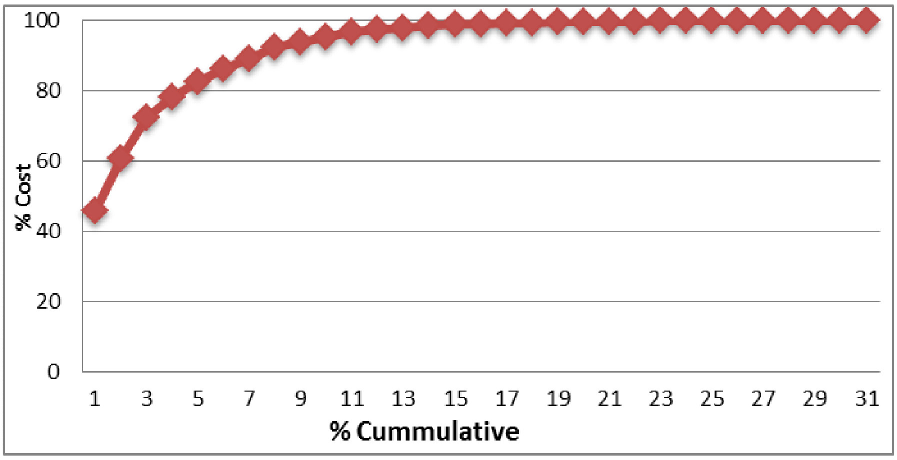

Figure 1: Pareto Analysis Graph of Under Bridge Works of Lamnyong Bridge Doubling in Banda Aceh

The method used in the creative phase of this research is brain storming method. This method is one of the methods that is often used in creative phase to produce the ideas related to other methods used to carry out the function. For cost/worth ratio value can be shown in Table 2 below.

Table 2: Cost\Worth on Foundation Work Item

Construction	Creative Phase					
Bridge	Function analysis					
Lamnyong	Item: Foundation					
Banda Aceh	Function : Load restrain to the bridge					
No	Component	Function		P/S	Cost	Worth
		Noun	Verb			
	Divisi Struktur					
1	Medium quality concrete with fc'=30 MPa (K-350)	Floor Concrete	casting	S	3.169.152.516,03	-
2	Medium quality concrete with fc'= 25 MPa (K-300)	Trotoar	casting	S	2.603.791.422,92	-
3	Medium quality concrete with fc'= 20 MPa (K-250)	Trotoar	casting	S	438.181.767,03	-
4	Low quality concrete with fc'= 15 MPa (K-175)	Work floor	casting	S	144.604.980,25	-
5	Girder Precast Unit of Type I	girder	precast			
	? Span is 26,6 meter			S	4.293.102.138,08	-
	? Span is 31,6 meter			S	2.249.950.754,04	-
6	Deck Slap Procurement			S	1.151.898.750,00	-
7	Concrete Diaphragm K350 (fc' 30 MPa)	Concrete	Distance	S	243.758.492,89	-
	(post-tension)					
8	Reinforsing steel of plain BJ 24	Structure	Strengthen	S	69.884.952,02	-
9	Reinforsing steel of screw BJ 32	Structure	Strengthen	S	10.987.079.719,29	-
10	Sheet Pile	Joint	Distance	S	1.031.736.309,20	-
11	Procurement of pile , size:	Procurement	coating			
	? Diameter : 500 mm and the thickness is 12 mm			P	33.738.468.578,31	33.738.468.578,31
12	Procurement of Precast Pre stressed Concrete Piles	Procurement	Load restrain			
	? Diameter : 500 mm			P	8.789.732.012,35	8.789.732.012,35
13	Pile staking of precast reinforced concrete.	Staking	Load restrain			
	? Diameter: 500 mm			P	2.229.916.489,86	2.229.916.489,86
14	Pile staking of steel pile	Staking	Load restrain			
	? Diameter : 500 mm and the thickness is 12 mm			P	468.942.593,28	468.942.593,28
15	Additional cost for item			P	177.431.847,91	-
	if the pilecarried out in the water					
16	Stone masonry	Couple	binding stone	S	24.528.668,31	-
17	rip rp	Couple	binding stone	S	3.374.616,04	-
18	Expansion Joint Tipe Asphaltic Plug	Joint	Distance	S	111.212.130,00	-
19	Elastomer placement of type 1 (300 x 350 x 36)	Put	sleeper material	S	147.349.752,90	-
20	Railing	Assemblies	Savety	S	337.720.326,50	-
21	Bridge Name Plank	Written	Bridge Name	S	1.666.964,03	-
22	Concrete Demolition	Material	Demolition	S	41.192.953,55	-
23	Demolition product transportation exceeding 5 km	Material	Demolition	S	4.289.461,92	-
24	Steel shower pipe			S	27.540.000,00	-
	TOTAL				72.486.508.196,71	45.227.059.673,81
	Cost/Worth				1,60	

On the abutment foundation and bridge pillar work items obtained cost/worth ration value is 1,60 or cost/worth value >1 then it can be continue to the function analysis phase. Then it is done the alternative replacement from the early design phase, in alternative 1 phase conducted design replacement on pillar 5 and pillar 6 foundations of early design foundation using steel piles foundations and then continue the alternative using precast prestressed concrete piles.

DISCUSSIONS

Alternative 1: Early design cost in pile foundation work is 72,486,508,196.71 IDR. After applying value engineering by replacing all foundations to precast concrete pile foundation, it is obtained the alternative cost become 40,616,598,222.56 IDR. The saving cost achieved is 31,869,909,974.15 IDR.

Alternative 2: Early design cost is 72,486,508,196.71 IDR. After applying value engineering by replacing all foundations to pile drill foundation, it is obtained the alternative cost become 41,699,143,562.9 IDR. The saving cost achieved is 30.787.364.633,81 IDR.

Alternative 3: Early design cost is 72,486,508,196.71 IDR. After applying value engineering by replacing all foundations to precast concrete pile foundation, and pillar 5 and pillar 6 are replaced with pile drill foundation using steel cassing that has the function to protect the foundation from the water so it is obtained the alternative cost become 41,243,208,716.9 IDR. The saving cost achieved is 31,243,299,479.77 IDR. Table 3 below shows the value engineering results to the three alternatives.

Table 3: Value Engineering Recapitulation

No	Work Item	Early Cost	Alternative Cost	Difference	(%)
1	2	3	4	5	6
1	Alternative I	72,486,508,196.71	40,616,598,222.56	31,869,909,974.15	43.97
2	Alternative II	72,486,508,196.71	41,699,143,562.90	30,787,364,633.81	42.47
3	Alternative III	72,486,508,196.71	41,243,208,716.90	31,243,299,479.77	43.10

Criteria ranking to see the value difference in value engineering recapitulation results. From the table above can be shown that the best alternative is alternative 1 by replacing all work items in foundations using precast concrete pile foundation.

CONCLUSIONS

Alternative sollution selected by considering the cost efficiency,easy of implementation and material quality. Based on the results of item analysis carried out to value engineering on pile foundations and bridge pillars. The highest cost item on steel pile work item is analyzed. In this item, steel piles are carried out to pillar 5 and pillar 6 which located under the water so it is necessary to coat the steel. By the additional of steel piles cause the higher price so that it needs to be applied value engineering for cost saving.

In value engineering application, there are three alternatives, they are alternative I used in all foundations of the bridge and the early design using precast concrete pile and steel pile, then is replaced the alternative using precast concrete pile to all bridge foundations. For alternative II, the early design is same with alternative I so this alternative is replace by pile drill foundation for all foundation items. For alternative III, the early design is same with alternative I and alternative II, they are replaced by precast concrete pile and for pillar 5 and pillar 6 are used pile drill foundation using steel cassing. After carrying out the value engineering, it is obtained that the most effective and efficient alternative design is alternative I by using precast concrete pile.

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